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Irrigated beans under no-tillage and conventional cultivation systems

[2]Thomas Jefferson Cavalcante, [1]Ricardo Francisco da Silva, [2]Tainara Mendes de Almeida, [2]Pedro Rogerio Giongo, [2]Lucas Freitas do Nascimento Junior, [2]Kássia de Paula Barbosa, [2]Arthur Almeida Rodrigues, [2]Roberto Gomes Vital

[1]Professor PhD, Agricultural Engineeering, Goias State University, Santa Helena de Goiás, GO, Brazil.
[2]Federal Institute Goiano, Campus Rio Verde, Brazil. Agronomy.

Address For Correspondence:
Jéssica Ferreira. Universidade de Brasília. Departamento de Engenharia Florestal. Faculdade de Tecnologia. 70.910-900. Brasília. Brasil.

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ABSTRACT

Common bean (*Phaseolus vulgaris* L.) stands out as one of the main crops produced in Brazil, an agricultural product extremely appreciated by Brazilians. Planting of crops associated with irrigation is a viable alternative, among cultural practices, in improving productivity. The objective of this study was to verify the effect of the presence and absence of dead cover (surface straw) and of different irrigation slides on the development and productivity of the bean crop. The soil used does not present evident erosion, with very small granular structure, very porous, soft, friable, plastic and sticky, excessively drained consistency, being classified as Red Latosol Eutrophric typical clay texture. The experimental design was divided into sub-divided plots, with four replications, with two plots with and without mulch on the surface, and subplots with 5 irrigation slides: 25, 50, 75, 100 and 125% of daily real evapotranspiration. To evaluate the productive agronomic characteristics, only the two central rows of each plot were considered as useful area, scoring 0.5m at each end. The evaluated parameters were: fresh mass, number of grains, number of pods, mass of 100 grains, production. Quantitative data were submitted to analysis of variance (ANOVA), followed by regression analysis. Conventional planting presented lower results than no - tillage in the characteristics evaluated, except for the production that obtained very similar values in both systems of planting. The no-tillage system provided better yields for the bean development, so that 100% irrigation would be recommended for the farmer.

INTRODUCTION

The common bean (*Phaseolus vulgaris* L.) stands out as one of the main crops produced in Brazil and it is an agricultural product widely appreciated by the Brazilian consumers, inserted in the country culinary habits, being one of the main protein sources in the population's diet (Paula Júnior *et al*., 2008).

Beans can be grown under no-tillage or conventional systems and the benefits of agriculture of conservation, which include no-tillage and reduced tillage practices (subsoiling, deep plowing), have been recognized for a long time and can be intensified with crop residues application (Souza *et al*., 2016). Soil crop residues protect soil and reduce soil erosion (Brouder and Gomez-Macpherson, 2014). This practice can also improve soil fertility and quality, mainly by increasing its organic matter (Bhattacharyya *et al*., 2012, Bhattacharyya *et al*., 2013, Jemai *et al*., 2013).

Santana *et al*. (2008) reported that irrigation is a viable alternative for improving crop yields, and that its basic purpose is to provide water aiming to achieve the crop water requirements. Irrigation is performed with the purpose of supplying the water deficit and provide conditions in which the crop could achieve its maximum yield.

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During the 2016 crop year, the beans production in Brazil was 3,296,411 tons, presenting an increase of 6.1% when the number is compared to the previous year (IBGE, 2016). The study of systems that can increase crop production with the use of techniques, such as irrigation, are of fundamental importance due to the scarcity of water resources and the fact that irrigated agriculture is one of the sectors that demand more water, but most grows in Brazil. In this way, new knowledge about the actual water needs of the crops is of extreme importance to growers (Morais *et al*., 2008; Santana *et al*., 2009; Cunha *et al*. al., 2013).

Thus, the aim of the present study was to verify the effect of the presence and absence of mulch (cover straw) and of different water depths on beans development and yield.

MATERIAL AND METHODS

The experiment was installed in the experimental field of the Goias State University, Santa Helena de Goias Campus, GO, Brazil (18º03'S, 50º35'W and 572 m altitude).

According to (CLIMATE-DATA.ORG), the municipality of Santa Helena de Goias has a tropical climate. There is less rainfall in winter than in summer and according to Köppen and Geiger, the climate classification is Aw, with 24.3°C of average temperature, and with higher temperatures in September (25.7°C) and lower temperatures in June (21.9 ° C). The annual average rainfall is 1539 mm and the driest month is July (10 mm), with higher rainfall incidence in December (279 mm).

The relief varies from soft-wavy to flat, and the predominant vegetation is the native forest, known as Cerradão. As an origin material there is a predominance of basalt, and the soil presents no evident erosion, with very small granular structure, very porous, soft, plastic and sticky consistency, excessively drained, being classified as a typical clayey eutrophic red latosol (Rosa *et al*., 2003).

The experimental design was divided into sub-divided plots, with four repetitions, with two plots with and without mulch on the surface, and subplots with 5 irrigation treatments (water depths): 25, 50, 75, 100 and 125% of the real daily evapotranspiration.

The soil analysis was performed before planting, for acidity corrections and basic fertilization. In the conventional preparation of the soil, it was used a plowing system with intermediate grid and light harrowing. Crotalaria was planted on 12/1/2013 and cutted on 03/08/2014.

The planting was carried out with pearl beans, popularly known in Brazil as 'carioquinha' beans, planted on 03/20/2014. The experimental plots consisted of four rows 4 m long and spaced at 0.45 m. The final average population was 116,273 plants.ha^{-1}. The fertilization was carried out with NPK in the formulation of 08-20-18, where 384 kg.ha^{-1} was applied at the time sowing, according to the soil analysis recommendatios, as well as N fertilization with 200 kg.ha^{-1}of urea, performed 23 days after sowing.

The experimental plots consisted of no-tillage or conventional planting systems, with 5 water depths (25%, 50%, 75%, 100% and 125% of daily evapotranspiration).

The irrigation system consisted of apump of 1-cv motor, a 1,000-liter tank, the distribution system with the main line and a log of the lateral line for each applied water depth (treatments), being installed in each planting line a drip tape, with emitter outputs spaced at 0.2m.

The reference evapotranspiration (ETo) was obtained using a tank installed close to the experimental area. Irrigation was performed in order to daily replace the bean evapotranspiration(ETc). Equations 1 and 2 were used to obtain ETc and ETo, respectively.

The determination of the total chlorophyll content was performed on fully expanded leaves using a portable chlorophyllometer (chlorofiLOG, CFL1030 model, Falker, Brazil).

Equation 1:

$$ETc = ETo.KC$$

Where:

ETc is the crop evapotranspiration (mm day^{-1});

Kcis the crop coefficient which presented values of 0.4; 1; 0.81; 1;0.6and mean of 0.75, according to Doorenbos and Pruitt (1977) and Allen*et al*. (1998).

ETo is the reference evapotranspiration (mm day^{-1})

Equation 2:

$$ETo = Kp.ECA$$

Where:

Kp is the tank coefficient (0.8)

ECA is the water evaporation in the tank (mm day^{-1}).

A 90% of efficiency in the application was considered for this study, considering the drip system.

In Figure 1 is possible to observe the means of internal (shadow) and external temperature values obtained from the sensor, at the Meteorological Station, considering the average variation of the period near to 25°C.

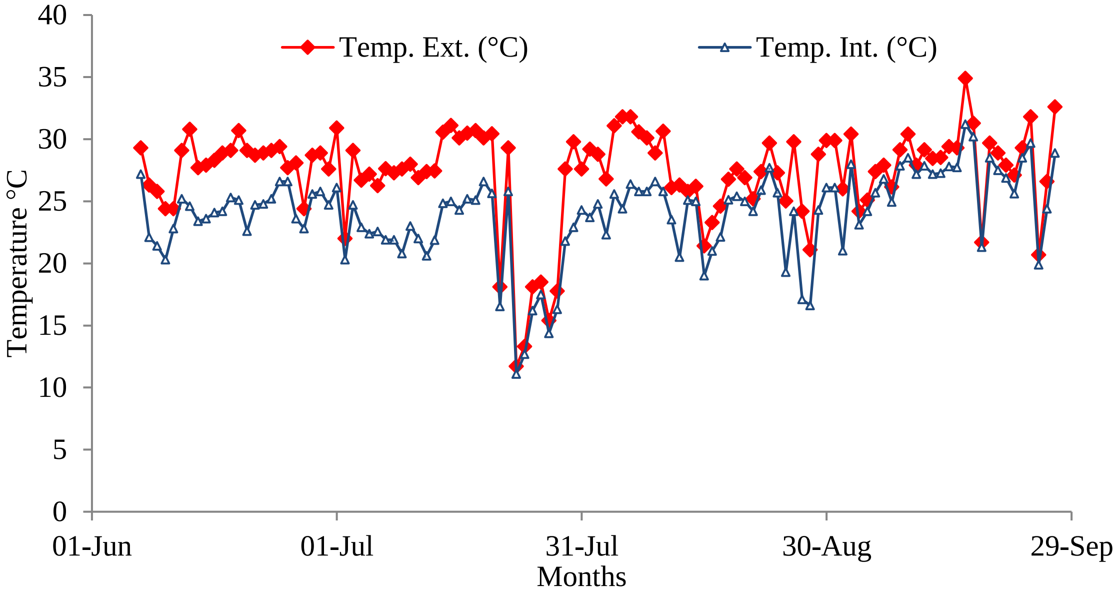

Fig.1: Means values for daily internal (int) and external (ext) temperatures (°C), collected at the meteorological station sensor shelter.

The Figure 2 indicates a decrease in daily relative humidity values and an increase in evaporation during the beans cultivation.

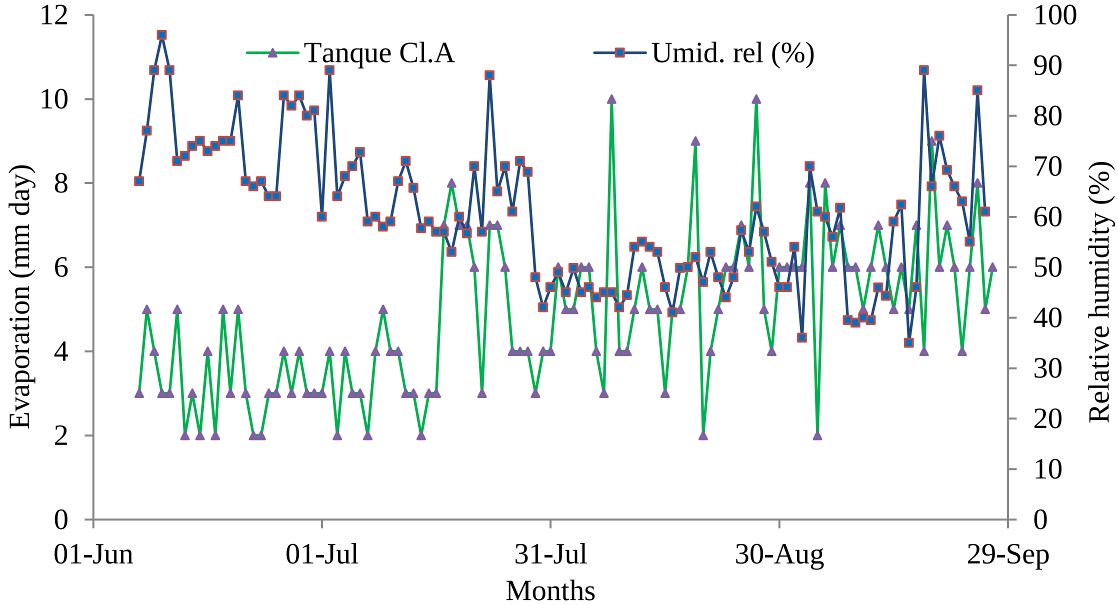

Fig.2: Means values for evaporation in the tank (mm day^{-1}) and relative humidity (%), obtained at the local meteorological station.

The treatments against weeds and pest control were performed when necessary.

To evaluate the productive agronomic characteristics, only the two central rows of each plot were considered as an useful area, not using the 0.5m of each end. The evaluated parameters were:

• Shoot and root fresh mass (FM): weighing separately the aerial part and root of plants of the useful area at the moment of the harvest, converting values to Kg.ha^{-1};

• Number of grains per plant: the average count of the number of grains in a sample of 3 plants of the useful area was performed;

• Number of pods per plant: the average number of pods was measured in 3 plants of the useful area;

• Hundred grain mass: in a sample of 1000 grains harvested in each plot, and the average weight for 100 grains.

• Yield: all grains of the useful area of each plot were harvested, and the weight was converted to Kg.ha^{-1}.

Quantitative data were submitted to variance analysis (ANOVA), followed by regression analysis.

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RESULTS AND DISCUSSION

The greater efficiency of the use of the water depths was observed in the no-tillage system with increments for the variables of total chlorophyll, hundred grain mass, number of pods per plant, plant green mass, number of grains per plant and yield, according to water depth increase (Figure 3). Conventional cultivation resulted in lower values for the variables when compared to the no-tillage system of production, except for yield, when the observed values were similar for the two evaluated systems (Figure 3F).

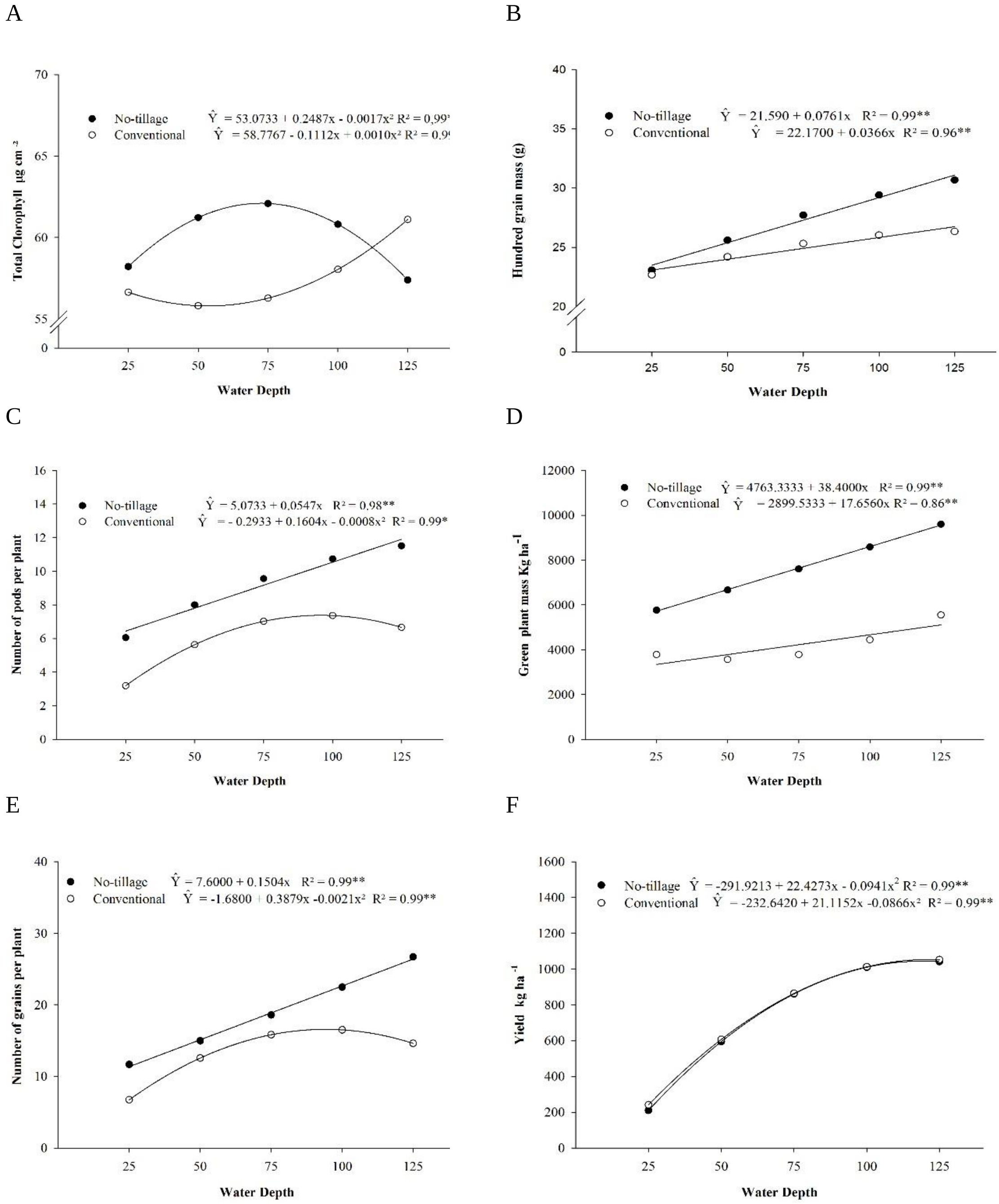

Fig. 3: Evaluated agronomic characteristics. (A) Total chlorophyll, (B) Hundred grain mass, (C) Number of pods per plant, (D) Green plant mass, (E) Number of grains per plant, (F) Yield.

The variable hundred grain mass has fundamental importance due to the fact that through this value is possible to analyze the grain productivity, with a direct relation to the crop yield. According to the Figure 3B, is possible to observe better results for variables when the no-tillage system was used, with water depths of 75 and 100%.

The efficiency of water use is related to the biomass accumulation and adopted techniques to increase the efficiency of the water used in irrigated agriculture. The use of drip irrigation with high frequency of water supply and in low volume was adequate (Srinivas *et al*., 1989).

Using the water depth of 125%, the highest green mass content was obtained, and the lower values was observed when the treatment of 25% was applied (Figure 3 D), verifying, therefore, that the available water has a direct relation with the crop vegetative development. For the number of pods, there was an increase in relation to the water depths between a no-tillage (64.72% higher) and conventional systems. Silva *et al*. (2007), observed the mean of 5.98 pods per plant, a value higher than the observed in the present study when the conventional system was used, but lower, when compared to the no-tillage system. For the variable number of grains per plant, it was also observed a difference according to the system used, with higher values observed with the use of the no-tillage system, with an increase in 69.95%.

The excess of water (125%) resulted in a decrease of values for the variables hundred grain mass, number of pods, number of grains per plant and yield. Similar behavior was observed by Torres *et al* (2013). The supply of adequate amounts of water is one of the fundamental factors in the production of the bean crop, since both excess and deficit can impair the crop development and yield, not exceeding the recommended irrigation (Arf *et al*. 2004).

The irrigation with 100% of water provided better results for the evaluated characteristics, confirming that the crop is sensitive to the excess and lack of water (Figueiredo *et al*., 2006). Other studies also confirm that common beans under stress presented lower number of pods per plant (Miorini *et al*., 2011 and Stone *et al*., 1988) and lower number of beans per pod (Carvalho, 2013).

Conclusion:

The use of drip irrigation with high frequency and low volume water supply was adequate, however, the excess of the applied lamina (125%) showed a decrease in the agronomic characteristics evaluated.

The no-tillage system provided better yields for the bean development, so that 100% irrigation would be recommended for the farmer.

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